DOCUMENT RESUME

ED 245 929 SE 044 663

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TITLE An Experimental Test of an Extended Discretion Laboratory Approach for University General Biology.
PUB DATE 29 Apr 84
NOTE 9p.; Paper presented at the Annual Meeting of the National Association for Research in Science Teaching (57th, New Orleans, LA, April 29, 1984).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Academic Achievement; *Biology; *College Science; Conventional Instruction; Higher Education; *Learning Strategies; Science Education; *Science Instruction; Teaching Methods
IDENTIFIERS *Extended Discretion Approach; Science Education Research

ABSTRACT

This investigation tested in a university setting a laboratory teaching approach found to be productive in high school settings. The extended discretion approach (ED) gives the student a task, from two to five brief procedural steps, and a list of resources from which to choose. The student must exercise discretion in the use of available resources to complete the task. General biology students (N=222) using this approach were compared to students (N=247) receiving conventional instruction. The criterion variables were student scores on a multiple-choice laboratory examination, on laboratory reports, and on six quizzes. Results showed significant differences between groups only for the laboratory reports; and these favored the conventional approach. In addition, results obtained for a treatment group by instructor analysis also showed significant differences for the laboratory reports. Since students performed at least as well using a learning method which is more demanding and challenging than by using another method, there is still reason to consider further the more challenging approach. If it can be shown that the ED approach does actually foster independence as well as allow students to learn biology laboratory concepts to at least the degree of a conventional approach, the ED approach may have some merit. (Author/JN)

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AN EXPERIMENTAL TEST OF AN EXTENDED DISCRETION LABORATORY APPROACH FOR UNIVERSITY GENERAL BIOLOGY

A Paper for the NARST Annual Meeting, New Orleans on 29 April 1984

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Since the massive government funding for experimental science curricula of the 1960s, the inquiry learning model has been one dominant focus of research in science teaching. The basic intent of the inquiry approach was to have the student think, discover and experience, first hand, the methods of science rather than be told science concepts via the one-way teacher lecture. The research reported here evolved out of the development of a variation of the inquiry model called the Extended Discretion (ED) laboratory approach and was developed as an alternative to existing, overly prescriptive, laboratory programs for secondary science (Cavana 1973, Leonard 1980a).

The ED approach engages students in systematic use of individual discretion as a strategy for learning science concepts and science processes, and has been described in detail for use in high school biology (Leonard 1980a, Leonard, Cavana, and Lowery 1981). In this approach, the student is given laboratory assignments without detailed procedures to follow. Instead, there is a task, from two to five very brief steps leading him/her through the task, and a complete list of resources available (including techniques). The student must then exercise discretion in the use of available resources in order to complete the task. The task statement is behavioral and specific, for example, "Find the effects of light intensity upon photosynthetic rate".

The educational and social justification of the ED approach lies in the idea that the ability to exercise discretion has been found to be closely correlated to occupational status in the working world (Jacques, 1964). If discretionary ability is so important, should it not also be fostered, even taught, in school? It is reasoned that a noble goal in education would be to extend each student's discretionary capacity to the maximum of his/her individual potential.

The ED approach was tested experimentally during an entire year in high school biology and was found to yeild more learning of biology concepts and science processes for certain variables than the commercial BSCS Green Version laboratory program (Leonard, Cavana, and Lowery 1981).

Hypothesis

The extensive training for and measure of individual discretionary ability, as important as it is, is far beyond the scope of this experiment. This research is simply to test a learning approach (ED) for university students which was found previously to be productive at the secondary level. It was hypothesized that there would be no significant difference on mean scores for three criterion variables between students learning under a guided inquiry (BSCS-style) laboratory program compared to the students learning under the extended discretion approach. Rejection of the hypothesis would tend to support the treatment for which there was higher student performance. Acceptance of the hypothesis would lend moderate support to the ED approach, since requiring students to learn under increased discretionary demands and with increased independence are consistent with contemporary goals in science education.

Method

The experimental sample was 469 students taking General Biology at the University of Nebraska during Fall 1982. Twenty-four laboratory sections containing eleven to 27 students each were randomly assigned to one of two treatment groups. Experimental group students (n=222) were to learn in a

laboratory classroom setting under the ED approach for an entire semester. Comparison group students (n=245) were to learn under the previous laboratory program which has been characterized as a guided inquiry or BSCS-style approach (Leonard 1980 b). The 24 laboratory classes were taught by one of ten instructors in the program. Each instructor taught at least one experimental and one comparison class teaching approaches.

The new ED program was written during the Fall of 1982 resulting in 12, 3-hour laboratory activities, each activity matched conceptually to the corresponding activity in the comparison program and had the same, factual, conceptual, and skill objectives. All students spent three hours per week for a total of 12 weeks in the laboratory classroom.

The independent variable, more opportunity for discretion through less direction in the laboratory proecdures, was checked systemimatically by counting the number of words of required procedures in each of the investigations carried out by the students. In addition, fifteen students each in the ED and guided-inquiry groups were selected at random and breifly and informally interviewed and asked (1) how they view both the difficulty of the investigations and (2) whether they feel they are learning science. Both of these latter measures were done to learn if differences between experimental treatments actually existed.

There were three quantitative criterion variables for all 469 students in this experiment 1) student scores on a multiple choice laboratory exam; 2) student scores on laboratory reports, and; 3) student scores on six laboratory quizzes given during the semester. The laboratory exam contained 50, 5-choice items with each laboratory topic being represented by at least 4 items. The exam was developed the prior semester and administered on a trial basis to 83 students who were taking the course at that time. The trial run of the exam yeilded a KR-20 value of .66. The exam was subsequently revised for this experiment based upon intra-topic correlation data, item analysis data, and qualitative content analysis. When the exam was finally administered to the experimental population a KR-20 value of .81 was achieved.

The 12 laboratory reports were scored subjectively by the instructors responsible for each respective class according to uniform guidelines established by the investigator. The six quizzes each contained five, short-answer questions. They were written by the investigator and scored by the laboatory instructors according to specific guidelines provided by the investigator.

Results

Data for treatment verification are given in Table 1. The mean number of words of required procedure for the student was 161.3 for the ED group and 526.7 for the comparison group. Since there appeared to be noticable differences of words of required procedure within each approach, a $\underline{t}^*$ test was empolyed for differences between these means. Differences of words of required procedure between the two treatments was found to be statistically significant ($\underline{t}^*_{12} = 4.39$, $p < .01$).

Table 2 gives the experimental data for the two groups on the three criterion variables. Table 3 gives the multivariate analysis on these data. Between group variance was found to be significant (>.001). As for many

studies with multiple instructors, between instructor variance was also found to be significant (<.001). Group by instructor interaction was also found to be significant (<.001).

In an attempt to further identify contributing factors in the study, univariate F tests were done on the three criterion variables. These are shown in Table 4. When a between groups analysis is considered, significant differences occur between groups only for the laboratory reports (<.001) and these favor the conventional approach. When a between instructors analysis is considered, there appears to be significant differences (<.001) across instructors as a whole for all three criterion variables. When a treatment group by instructor interaction analysis is considered, significant differences appeared to occur only for the laboratory reports (<.01).

Since the only criterion variable which showed significant differences between groups (laboratory report scores) also showed significant group by instructor interaction, further analysis was considered inappropriate. The hypothesis of no difference therefore stands unrejected for all criterion variables.

Because the interviews of participating students was very casual and because the qualitative responses varied greatly (as expected), these data were mostly intended to be antidotical. However, when asked about the difficulty level of the approach, phrases such as "I find it hard", "It makes me think", or "It was confusing at first" were characteristic of students using the ED approach and phrases such as "I found it easy" or "All we need to do is read the directions" were characteristic of students using the guided-inquiry approach. When asked if they felt they were "learning science" most students in both groups seemed uncertain, several implying or stating that they did not know what "science" actually was. Seven students from the ED group and three from the guided-inquiry group answered "Yes" to the question, whereas two from the guided-inquiry group only, answered "No" to the question. Although no attempt to statistically analyze these antedotical data was made, it appeared that the students perceived some very real, qualitative differences between the two approaches.

Significance

The major characteristic of the extended discretion teaching approach is much less direction or procedure required of the student in order to carry out the laboratory activity. The student is given a focusing statement (Goal), a few limited procedures of a sentence or two each (Steps), and extensive resources from which to choose (Information and Techniques). Because of limited procedure to follow, the student is forced to develop and/or select many of the procedures for themselves. Based upon a measured difference in the volume of procedure between the extended discretion and the guided inquiry approaches tested experimentally here, and based upon student verbal responses to specific questions about the approaches, it is assumed that the ED approach required more of the student's individual discretion than the conventional laboratory approach. In short, students using a ED approach need to be relatively inventive. Students in the ED approach commented rather consistently that the approach was more challanging to them and represented "real science" more than conventional approaches they were accustomed to. On the other hand, students in the conventional approach felt the laboratory work to be rather easy and did not comment that it represented real science any

more than did their past science experiences.

One would predict that if learning if comparatively difficult for a student, the student would not perform as well as learning under an easier approach. However, when the ED laboratory learning approach was tested experimentally against a more conventional (guided inquiry) approach for an entire semester in a university general biology course, no significant differences were found in student performance between the two approaches.

Among the goals of a general education are to foster skills in independent thought and in making decisions. These goals are also prevalent in the major alphabet science curricula, such as BSCS, developed over two decades ago and are still among the highest priorties of science teaching today.

If students can perform at least as well using a learning method which requires more responsibiliby on the part of the student for planning the procedure of the investigation than by using another method, there is still reason not to reject the more challenging approach. If it can be shown that the ED approach does actually foster independence and the development of discretionary skills as well as allow students to learn biology laboratory concepts to at least the degree of a conventional approach, laboratory learning approaches which make significantly more demands upon student discretion than existing approaches should be explored further. A valid and reliable inventory of individual discretionary ability would need to be developed. Further experiments are necessary to test this hypothesis and at the same time control for instructor variance.

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TABLE 1

NUMBER OF WORDS OF REQUIRED PROCEDURE BETWEEN AND EXDENDED DISCRETION AND GUIDED INQUIRY LABORATORY LEARNING APPROACH

Investigation Topic	Extended Discretion	Guided-inquiry
Microscope Use	264	1452
Biomes	180	384
Behavior	73	264
Cell Functions	143	780
Transport	132	804
Enzymes	59	300
Photosynthesis	118	864
Respiration	60	359
Reproduction	107	349
Heredity	283	444
Evolution	322	543
Diversity	195	328
SUM	1963	6872
MEAN	161.3	526.7
S.D.	89.0	348.0
$\underline{t}^*$ 12	4.39 ($p<.10$)	

Table 2

Scores Groups on Three Criterion Variables for Students Learning by Two Different Laboratory Teaching Approaches

	Guided Inquiry (n=245)		Extended Discretion (n=222)	
VARIABLE	MEAN	S.D.	MEAN	S.D.
Lab Quizzes	44.00	7.78	43.78	7.68
Lab Reports	114.77	7.22	110.61	11.48
Lab Exam	51.15	6.47	51.76	6.20

Table 3

Multivariate Analysis on Three Criterion Variables for Students Learning by Two Different Laboratory Teaching Approaches

SOURCE	D.F.	F-ratio	SIG
Treatment Group	3,454	24.82	<.001
Lab Instructor	30,1333	11.15	<.001
Group X Instructor	27,1326	3.01	<.001

Table 4

Univariate F-tests on Three Criterion Variables for

Students Learning by Two Different Laboratory Teaching Approaches

Between Groups (d.f. = 1,456)

VARIABLE	HYPOTH. SS	ERROR SS	HYPOTH. MS	ERROR MS	F	SIG.
Quizzes	12.48218	26677.11568	12.48218	58.50245	.21336	.644
Lab Report	2985.24673	40642.60658	2985.24673	89.12852	33.49373	.000
Lab Exam	59.83782	18352.18272	59.83782	40.24601	1.48680	.223

Between Instructors (d.f. = 10,456)

VARIABLE	HYPOTH.SS	ERROR SS	HYPOTH. MS	ERROR MS	F	SIG.
Quizzes	4065.51179	26677.11568	406.55118	58.50245	6.94930	.000
Lab Report	8847.69336	40642.60658	884.76934	89.12852	9.92689	.000
Lab Exam	2514.49052	18352.18272	251.44905	40.24601	6.24780	.000

Group X Instructor Interaction (d.f. = 9,456)

VARIABLE	HYPOTH.SS	ERROR SS	HYPOTH. MS	ERROR MS	F	SIG.
Quizzes	713.11982	26677.11568	79.23554	58.50245	1.35440	.207
Lab Reports	2375.48690	40642.60658	263.94299	89.12852	2.96138	.002
Lab Exam	339.58118	18352.18272	37.73124	40.24601	.93751	.492